AN2501
Application note

ST10 electric motor control library
Current sensing driver

Introduction

STMicroelectronics provides a library of electric motor control functions that can be used as base blocks for electric motor control applications.

This application note describes the set of API to implement a current sensing strategy in electric motor control applications.

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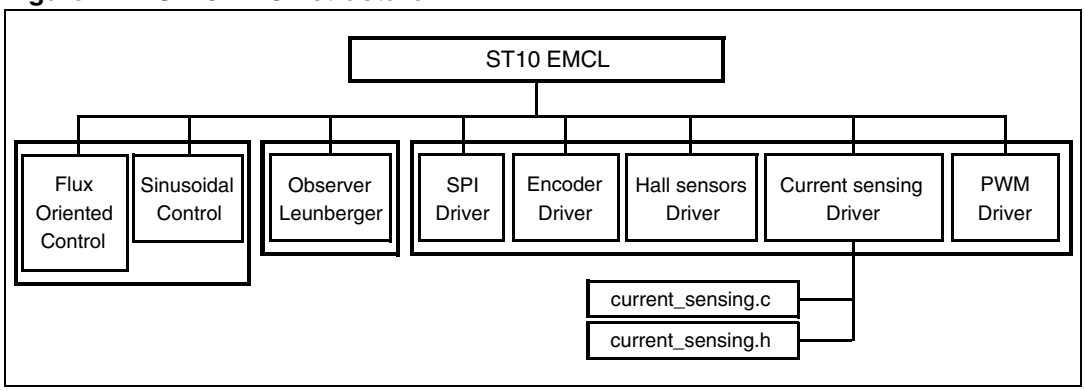
1 Functions set overview

The current sensing driver is a set of functions included in ST10 electric motor control library (EMCL) (see *Figure 1*) useful to process the measurements of current in electric motor control. This document explains how to use two ADC channels to sample the currents on 2 shunt resistors at specific instants. In particular on one shunt resistor the current is measured as instantaneous value and on the other shunt resistor as average value.

A brief overview on current sensing strategy is given in section *Chapter 1.1*.

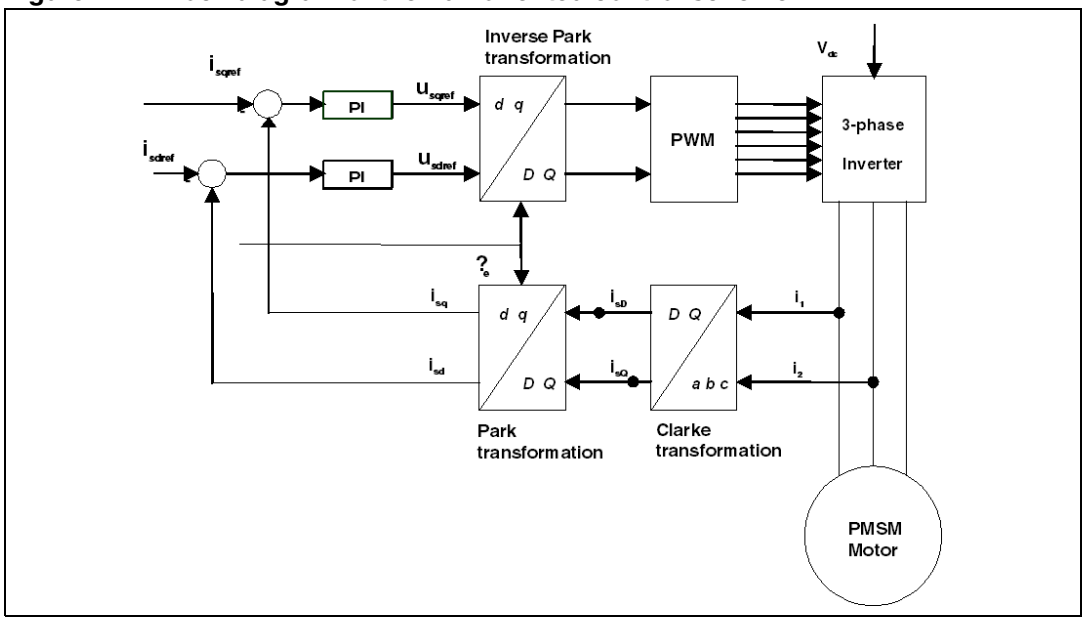
Figure 1. ST10 EMCL structure



1.1 Overview on current sensing strategy

The flux oriented control (FOC) is based on a current controlled voltage source inverter (VSI) structure to generate a desired voltage space vector that the inverter applies to the motor phases by means of the measurement of the electric motor phase currents (see *Figure 2*) and a continuous modulation method (modulation period T) .

Figure 2. Block diagram of the flux oriented control scheme



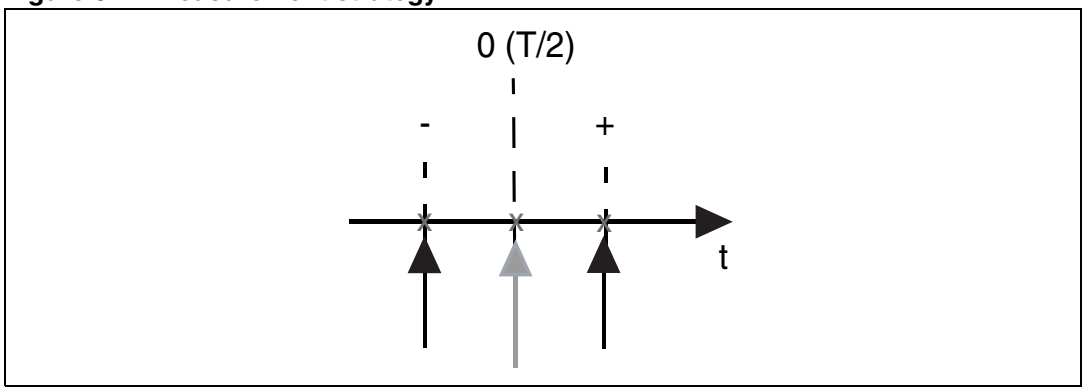
The transformations from a stator frame to a rotor frame that are the core of FOC need the sampling of three phase currents in the modulation period T. The sampling can be reduced to only two phase currents if the motor windings are star-connected.

In this case the acquisition of two current signals can be done with two different A/D converters or using only one A/D converter multiplexed on two (or more) channels, a solution less expensive than the first one where the acquisitions are sequential.

Independently from the used current sensor, this second choice introduces some measurement errors. In order to reduce these errors, one conversion is done at the time 0 (or T/2) where the contribution of harmonic current components is minimum, while the second current is calculated as average value sampling in two different instants [(0 $\pm\delta$) or (T/2 $\pm\delta$)] centred compared with the acquisition on the other phase (see *Figure 3*) with a gap δ bigger than the conversion time of the A/D converter. In particular δ is chosen equal to T/2. So only two measurements for modulation period are needed.

In this document the current sensing strategy with one ADC is described.

Figure 3. Measurement strategy



2 API specification

The following API allows easy access to the described current sensing strategy configuring the ADC channels (c1 and c2) in Injection Mode to sample the motor currents from each channel sequentially, reading and processing these values.

The use of these functions eliminates the need to access the ST10 registers directly.

The available functions are:

1. void Current_sensing_Init(CS_UINT16 sPeriod)
2. void Current_sensing_Start(void)
3. void Current_sensing_Register(CSFUNCTION csfunction)

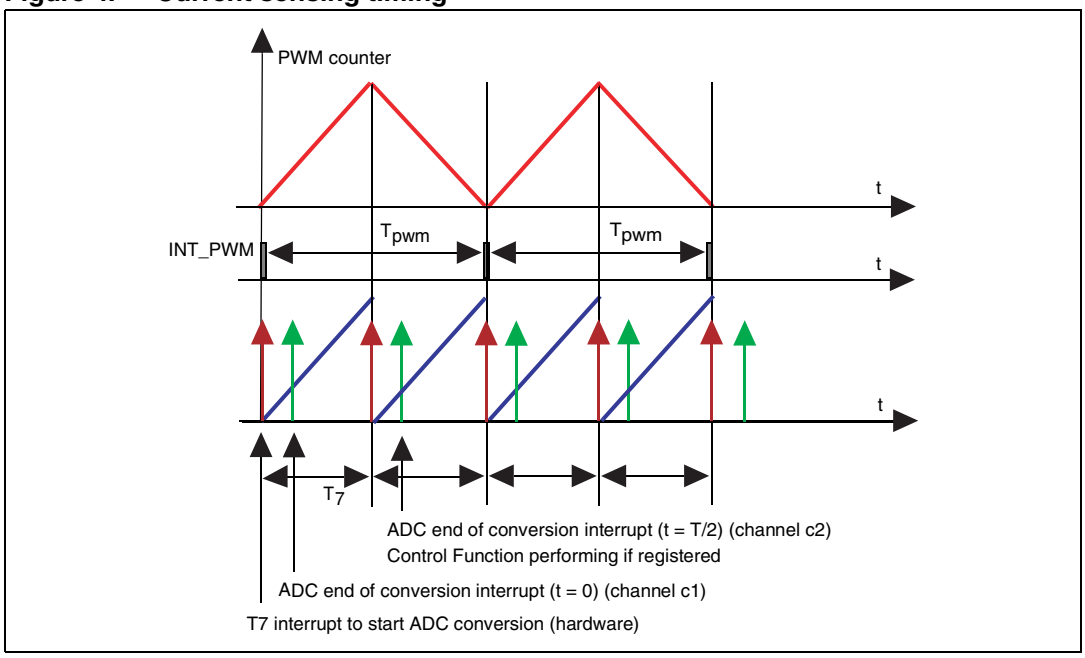
see file current_sensing.c in the EMSW_CS Library.

2.1 Synchronization of signals

The sampling of the ADC is synchronized with the PWM. The CAPCOM timer T7 is synchronized with the PWM semiperiod (i.e. PWM timer and CAPCOM T7 are started in the same instant with consecutive instructions) so that the Injection Request bit for ADC is set by CAPCPOM channel CC31 in the instants 0 (channel c1 acquisition) and T/2 (channel c2 acquisition). The current on channel c2 is calculated as average value of the present value and the value sampled in the previous period.

This means that the current values are available for the control only in the 2nd semiperiod of the PWM period. If a control function is registered, this function will be performed at each mid point of the PWM period (t = T/2), i.e. at each end of conversion for the channel c2. Control Function performing if registered.

Figure 4. Current sensing timing



2.2 Functions definition

In the following the functions for configuring two ADC channels in Injection Mode, to read and to process the results of ADC conversions so as to implement the currents sensing strategy with one ADC are described.

2.2.1 Current_sensing_Init

Prototype definition:

void Current_sensing_Init(CS_UINT16 sPeriod)

Parameters:

Table 1. Current_sensing_Init parameters

Configuration Parameters	Description
c1	channel number (0, ..., 9)
c2	channel number (0, ..., 9)
Global Parameters	
csValue	variable to store current value (0)
csValue_temp	static variable to store current value (T/2)
csFunction	pointer to the control algorithm function
Function Parameters	
sPeriod	sampling period (number of mcu clock tics)

Description:

The Current_sensing_Init function is used to configure two ADC channels (c1 and c2) in Injection Mode and to convert a specific analog channel triggered via software at every compare event of compare register CC31 on Timer 7, which sets Injection Request bit (ADCRQ), synchronizing the sampling of the motor currents with PWM period.

It is needed to set the two ADC channels (0...9) connected to the current sensors by means of parameters (c1 and c2) inside the function.

2.2.2 Current_sensing_Start

Prototype definition:

void Current_sensing_Start(void)

Parameters:

Table 2. Current_sensing_Start parameters

Configuration Parameters	Description
c1	channel number (0, ..., 9)
c2	channel number (0, ..., 9)
Global Parameters	
csValue	variable to store current value (0)
csValue_temp	static variable to store current value (T/2)
csFunction	pointer to the control algorithm function
Function Parameters	
none	

Description:

The Current_sensing_Start function is used to start the Timer 7 and the current sensing by interrupt.

2.2.3 Current_sensing_Register

Prototype definition:

void Current_sensing_Register(CSFUNCTION csfunction)

Parameters:

Table 3. Current_sensing_Register parameters

Configuration Parameters	Description
c1	channel number (0, ..., 9)
c2	channel number (0, ..., 9)
Global Parameters	
csValue	variable to store current value (0)
csValue_temp	static variable to store current value (T/2)
csFunction	pointer to the control algorithm function
Function Parameters	
none	

Description:

The Current_sensing_Register function is used to point to the control algorithm function. It is needed to declare in the main a user function with the algorithm control and register it so that the algorithm can be executed at every end of conversion on channel c2.

2.3 Resource

For the use of Current sensing Driver the needed resources are:

ADC (2 channels)	ADC
Compare Timer (Timer 7)	CAPCOM Timer
Compare register (CC31)	CAPCOM register
Bank register (RB08)	ADC Interrupt Service Routine

3 Revision history

Table 4. Document revision history

Date	Revision	Changes
12-Mar-2007	1	Initial release.

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